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RESEARCH ARTICLE

Genetic Variability Analysis among Advanced Wheat Cultivars (*Triticum aestivum* L.)

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ABSTRACT

Wild plant species are one of the major sources of variation that can be used to improve wheat and assist in dealing with issues resulting from climate change and the increasing human population. In the present work, we comprehensively investigated the genetic variability among various advanced wheat (*Triticum aestivum*) cultivars using several morphological and yield-related traits. In total, 25 advanced wheat lines along with a check cultivar (AWL25), were used in a randomized complete block design with two biological replications. The experimental work was performed considering numerous morphological and yield-related traits including days to heading, days to maturity, spike length, spikelets per spike, grain yield, biological yield, and 1000 grain weight. The result of variance analysis showed a significant level of genetic variability in all trials, however, most of the parameters were not affected by genetic variability. In the case of days to heading, the mean performance ranged from 103 (AWL18) to 115 (AWL8). Similarly, days to 90% maturity ranged from 156 for the cultivar (AWL18) to 162 for the cultivar (AWL14). Noticeably, the means of spike length were observed in the range of 9.37 cm for cultivar (AWL9) and 14.60 cm for cultivar (AWL7), whereas the spikelets per spike were 18.17 for AWL21 cultivar and 24.67 for AWL2. Furthermore, the biological, grain yield and 1000 grain weight were observed with some degree of genetic variation in their mean value. Altogether, this work highlights important yield-related traits to improve different wheat varieties by exploring the germplasm diversity in the wheat population, thus facilitating future breeding programs.

Key words: Wheat, Genetic variability, Morphological traits, Yield, Variance analysis

INTRODUCTION

Wheat is a member of the grass family, Poaceae. The bread wheat (*Triticum aestivum* L) is an allohexaploid (2n=6x=42), which is developed by two distinct natural hybridization events. The two grass species i.e. *Triticum speltoides* (B genome donor) and *Triticum urartu*, have been accidentally crossed into tetraploid wheat species termed *Triticum turgidum* (A genome donor) (Haroon et al., 2022). The hybridization of tetraploid (A genome donor) and *Triticum tauschi* (D genome donor) produced novel hexaploid wheat. It is a cereal grass belonging to the genus *Triticum*, and its grains are used as food. It is one of the oldest and most significant cereal crops (Goel *et al.,* 2018). *Triticum aestivum* L. (bread wheat), is the most important and widespread of the thousands of wheat types currently known. In temperate regions, the most common crop. Pasta like spaghetti and macaroni are made from durum wheat (*T. durum*). The flours, cookies, and cakes made from club wheat (*T. compactum*) are softer than those made from other types of wheat (Swain and Mohanty, 2018).

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Wheat is a good source of many nutrients and fiber when it is eaten as a whole grain. People get most of their food from wheat, but sometimes events occur that break the chain of access to wheat (Shewry and Hey, 2015). High-protein, hard wheat is used to make bread and other hard-baked goods. Hard red spring wheat is often used to make bread flour and high-gluten flour. The Minneapolis Grain Exchange is the main place where it is traded. Hard, brownish, mild, high-protein wheat is used to make bread and other hard-baked goods, as well as to add protein to other flour for pie crusts (Goel et al., 2018). Some brands of unbleached all-purpose flour are usually made from just hard red winter wheat. Marquis wheat was made so that it could grow well in Canada, which has a shorter growing season. It is now grown as far south as southern Nebraska (Goel *et al.,* 2018). Soft wheat which doesn't have much protein is used to make cakes, pie crusts, biscuits, and muffins. Soft red winter wheat is used to make cake flour, pastry flour, and some self-rising flours with baking powder and salt (Al-Tabbal and Fraihat, 2012). The Chicago Board of Trade is the main place where it is traded. Hard, light-coloured, cloudy, chalky wheat with a medium amount of protein that grows in dry, temperate areas. Used to make bread and make beer (Al-Tabbal and Fraihat, 2012).

Today, cereal grains are the single most important source of calories for most of the world's population (Awika, 2011). Punjab in Pakistan is the major food-producing province and is titled the “breadbasket” for the country's more than 220 million people. It is estimated that 25.8 MMT of wheat will be consumed in 2020/21, and 26.3 MMT in 2021/22 (Haroon et al., 2023). Khyber Pakhtunkhwa (KP) is a better place to grow wheat (Ali et al., 2023). It takes up 48% of all the land that is farmed in the province and 57% of the land that is used to grow cereals. During 2014-2015, wheat was grown on about 0.73 million hectares, and 1.25 million tonnes were produced (Ali et al., 2023). In this study, we extensively focused on the genetic variability of various wheat (*Triticum aestivum*) cultivars considering several morphological and yield-related traits. this work explores the wheat population's genetic diversity and emphasizes critical yield-related features to improve existing wheat varieties through genetic breeding. The objective of this research is to evaluate the genetic variability and heritability among different wheat cultivars and to facilitate a reference resource for future breeding programs for the improvement of wheat cultivars using these important morphological and yield-related traits.

MATERIALS AND METHODS

The research work was carried out at Cereal Crops Research Institute Pirsabak (CCRI), Nowshera, Pakistan. The CCRI is located at 34-degree North latitude, 72-degree East longitude, and 288-degree altitude. Experiments were conducted under irrigated conditions on 13 November 2021. The experiments were designed in a simple partially balanced lattice 8x8 with two replications. Each plot consisted of 4 rows of 2-meter length. The row spacing was 30 cm with a plot area of 2 m^2. A single row between adjacent plots was kept fallow to facilitate data recording. The agronomic practices and inputs were applied for all the entries from sowing to harvesting and the genotypes were grown under uniform conditions to minimize environmental variations.

Data Collection

Data were collected randomly from 5 Five plants in blocks of each replica on days to heading, days to maturity, plant height, flag leaf area, spike length, spikelets per spike, biological yield grain yield and 1000 grain weight.

Statistical Analysis

All the data was subjected to analysis of variance (ANOVA) using MSTAT-C computer software. After getting the significant variations among genotypes for various parameters, the means for each parameter were further separated and compared by using the least significant difference (LSD) test at a five percent level of probability**.** The plant materials used in this work consist of 25 Advanced Wheat Lines (AWL) and Gulzar-2019 as a check cultivar (Table 1).

RESULTS AND DISCUSSION

Genetic Variability and Mean Performance

In the present study all the traits are highly genetically variants, in the 25 advanced wheat lines along with check cultivar there is no significant performance among all traits except for biological yield and grain yield, including days to heading, days to maturity, flag leaf area, plant height, spike length, spikelets per spike, grain yield, 1000 grain weight (Table 2a and 2b) (Arya *et al.,* 2017; Yadav *et al.,* 2014) showed the opposite result in their previous works. Biological yield showed a significant result which was the same in the past work (Al-Tabbal and Fraihat, 2012). Grain yield also showed significant performance in their report investigation and compatibly same has been reported before (Arya *et al.,* 2017). The means performance for morphological traits for days to heading all wheat genotypes ranged 137 to 156. Among all the genotypes, a minimum number of days to heading was observed (137 and 152) for (AWL7) and (AWL4) respectively. The maximum number of days to 50% headings were recorded for (156 and 154) for (AWL18) and (AWL21) (Table 3). The coefficient of variance is varied for different blocks respectively. Analysis of variance shows non-significance of genetic variation for days to heading. The coefficient of variation (CV) was 3.21 at 5% probability showing 10.40 LSD (Least Significance Difference). Days to maturity in all wheat genotypes

Table 1: List of advanced wheat lines along with origin and parentage used in study during 2021-22 at CCRI Pirsabak Nowshera

S. No.	Line Name	Specific Name
1.	Synthetic E (18)/PS85//SUP152*2/TECUE#1/3/ NUWYT Noncoded Ent 48 (2015-16)	AWL1
2.	Synthetic E (18)/PS85//SUP152*2/TECUE#1/3/ NUWYT Noncoded Ent 48 (2015-16)	AWL2
3.	Synthetic E (26)/PS 85//CROSSBILL#1/FRNCLN/3/ SOKOLL/WBLLI	AWL3
4.	Synthetic E (26)/PS 85//CROSSBILL#1/FRNCLN/3/ SOKOLL/WBLLI	AWL4
5.	Synthetic E (26)/Inqilab 91//KACHU/KINDE/3/Trap Nursery Ent 32 (2015-16)	AWL5
6.	Synthetic E (26)/Inqilab 91//KACHU/KINDE/3/Trap Nursery Ent 32 (2015-16)	AWL6
7.	Synthetic E (58)/SEHER 06//PR 103/NARC 11/3/ Parula	AWL7
8.	PR106/Trap Nursery Ent 32(2013-14)// Durabi 13/3/WPEPYT 16(13-14)	AWL8
9.	PR106/Trap Nursery Ent 32(2013-14)//Durabi 13/3/WPEPYT 16(13-14)	AWL9
10.	/TATARA96//NING8319/3/IBWSN 132 (2015-16)	AWL10
11.	PR107/Trap Nursery Ent 12(2013-14)//Durabi 13/3/WPEPYT 10 (13-14)	AWL11
12.	PR107/Trap Nursery Ent 12(2013-14)//Durabi 13/3/WPEPYT 10 (13-14)	AWL12
13.	PR107/Trap Nursery Ent 29(2013-14)//Durabi 13/3/ NUWYT Noncoded Ent 37 (2015-16)	AWL13
14.	PR107/Trap Nursery Ent 29(2013-14)//Durabi 13/3/ NUWYT Noncoded Ent 37 (2015-16)	AWL14
15.	PR107/Trap Nursery Ent 29(2013-14)//Durabi 13/3/ NUWYT Noncoded Ent 37 (2015-16)	AWL15
16.	PR107/Trap Nursery Ent 29(2013-14)//Durabi 13/3/ NUWYT Noncoded Ent 37 (2015-16)	AWL16
17.	PR107/Trap Nursery Ent 29(2013-14)//Durabi 13/3/ NUWYT Noncoded Ent 37 (2015-16)	AWL17
18.	PR107/Trap Nursery Ent 29(2013-14)//Durabi 13/3/ NUWYT Noncoded Ent 48 (2015-16)	AWL18
19.	TATARA96//NING8319/3/IBWSN 132 (2015-16)	AWL19
20.	TATARA96 PAK81// PAK81NING8319/3/IBWSN 132 (2015-16)	AWL20
21.	PAK81/TATARA96//NING8319/3/IBWSN 132 (2015-16)	AWL21
22.	PAK81/TATARA96//NING8319/3/IBWSN 132 (2015-16)	AWL22
23.	PAK81/TATARA96//NING8319/3/	AWL23
24.	CHIBIA//PRLII/CM65531/3/FISCAL/4/SUP152/Punjab-11//Trap Nursery Ent 12 (2015-16)	AWL24
25.	Gulzar-19	AWL25

Table 2a: Sum of mean performance for days to heading, days to maturity, plant height and flag leaf area. VC= coefficient of variation LSD= least significance difference DF= degree of freedom *= significance **= non significance at 5% probability

Source of Variance	DF	Days to heading	Days to maturity	Plant height	Flag leaf area
REPS	1.00	48.02**	0.50**	3.38**	12.14**
Treatment Sum of Squares (unadjusted)	24.00	24.69**	6.71*	3.49**	42.03**
Blocks within Reps/ Block Sum of Squares	8.00	25.95	7.79	5.59	60.06
Treatment Sum of Squares (adjusted)	24.00	23.80**	6.95**	2.11**	46.94**
RCB (randomized complete block)	24.00	24.69	4.13	3.49	45.60
Intra block error	16	24	2.30	2.43	38.36
Total	50	-----	----	----	-----
CV%	---	3.31	0.95	4.29	16.36
LSD 5%	----	10.40	3.21	3.31	13.13

Table 2b: Sum of mean performance for spike length, spikelets per spike, biological yield, grain yield and 1000 grain weight. VC= coefficient of variation LSD= least significance difference DF= degree of freedom *= significance **= non significance at 5% probability

Source of Variance	DF	Spike length	Spikelets per spike	Biological yield	Grain yield	1000 grain weight
REPS	1.00	0.29**	0.64	2121800*	1960200.0*	0.00**
Treatment Sum of Squares (unadjusted)	24.00	2.15**	3.68	160804.17*	255649.29*	88.74**
Blocks within Reps/ Block Sum of Squares	8.00	3.41	12.40	413362.50	268562.50	86.69
Treatment Sum of Squares (adjusted)	24.00	2.21**	3.63	175836.00*	225779.97*	85.06**
RCB (randomized complete block)	24.00	3.41	5.59	188987.50	116659.38	72.99
Intra block error	16	3.41	2.19	76800.00	40707.81	66.14
Total	50	-----	----	----	----	----
CV%		15.42	6.88	8.05	8.11	15.44
LSD 5%		3.91	3.13	587.49	589.30	17.24

ranged between 156.5 and 163.5. Among all the genotypes, a minimum number of days to maturity was observed 156 (AWL12) and 157 (AWL3). While maximum number of days to maturity was recorded as 163 (AWL7) and 162 (AWL20). The coefficient of variance is varied for different blocks respectively. Among all the genotypes, the minimum plant height was observed for (AWL12) and (AWL11) (33.67 and 34.33 cm). The maximum plant height was recorded for each 39.67cm (AWL4) and 37.50 cm (AWL3). The analysis of variance showed a highly significant difference for flag leaf area among the tested 25 lines advance wheat d line. Flag leaf area in all wheat genotypes ranged between 31.57cm to 55.77cm. Among all the genotypes, minimum flag leaf area was observed (AWL9) and (AWL25) (31.37 and 32.53 cm^2). While maximum flag leaf area was recorded for 55.77cm^2 (AWL12) and 43.75cm^2 (AWL16) (Table 3a). The coefficient of variance was varied for different blocks respectively. Analysis of variance showed a non-significance of

Table 3a: Mean performance of days to heading, days to maturity, spike length, spikelets per spike in advanced wheat lines with coefficient of variance (CV) and least significance of difference (LSD) at 5% probability.

Entry name	Days to heading	Days to 90% maturity	Spike length	Spikelets per spike
AWL1	154.00	159.00	11.50	23.00
AWL2	154.00	160.50	11.37	24.67
AWL3	153.00	157.50	12.83	22.17
AWL4	152.00	161.00	11.75	22.67
AWL5	152.00	162.50	11.95	24.00
AWL6	152.50	161.50	10.62	22.33
AWL7	137.00	163.00	14.60	21.67
AWL8	154.00	158.00	9.83	20.67
AWL9	153.50	158.00	9.37	18.67
AWL10	153.50	158.50	11.22	21.67
AWL11	153.50	159.00	10.60	23.00
AWL12	154.00	156.50	11.92	23.67
AWL13	153.50	161.50	10.92	21.67
AWL14	153.00	162.00	12.87	20.67
AWL15	152.50	160.50	14.32	23.00
AWL16	153.00	161.50	12.20	19.33
AWL17	153.50	162.00	12.25	20.33
AWL18	156.00	161.50	11.12	20.67
AWL19	156.00	162.00	13.30	22.67
AWL20	154.50	162.00	12.25	24.00
AWL21	156.00	161.50	12.58	18.17
AWL22	154.50	159.50	14.38	19.83
AWL23	153.00	157.50	10.84	18.00
AWL24	154.00	159.00	11.70	20.33
AWL25	153.00	160.00	13.05	20.33
LSD 5%	10.40	3.21	3.91	3.13
CV	3.21	0.95	15.42	6.88

Table 3b: Mean performance of plant height, biological yield, grain yield, 1000 grain weight in advanced wheat lines with a coefficient of variance (CV) and least significance of difference (LSD) at 5% probability.

Entry name	Plant height	Flag leaf area	1000 grain weight	Biological yield
AWL1	37.17	31.93	50.75	3675.00
AWL2	37.00	35.40	53.10	3725.00
AWL3	37.50	41.18	18.10	3800.00
AWL4	39.67	35.50	48.85	3225.00
AWL5	39.67	40.63	62.70	3600.00
AWL6	36.67	38.87	52.05	3600.00
AWL7	35.83	38.27	43.95	3375.00
AWL8	36.33	36.67	52.70	3550.00
AWL9	36.00	31.57	51.75	3200.00
AWL10	35.83	39.27	47.70	3000.00
AWL11	34.33	39.02	53.90	3400.00
AWL12	33.67	55.77	51.10	3500.00
AWL13	36.17	33.62	59.35	3450.00
AWL14	35.67	34.83	57.50	3250.00
AWL15	36.67	37.32	67.70	3475.00
AWL16	36.67	43.75	59.25	3775.00
AWL17	36.67	37.57	60.70	3375.00
AWL18	36.67	32.83	57.25	3250.00
AWL19	36.33	41.83	46.11	2675.00
AWL20	37.33	42.53	57.85	3350.00
AWL21	36.50	42.40	52.85	3325.00
AWL22	35.67	37.25	51.90	3800.00
AWL23	35.00	29.68	57.35	3375.00
AWL24	35.83	36.40	50.35	3075.00
AWL25	35.33	32.53	52.20	4225.00
LSD 5%	3.31	13.13	17.23	587.49
CV	4.29	16.36	15.44	8.05

genetic variation for the flag leaf area. The coefficient of variation (CV) was 16.36 at 5% probability showing 13.13 LSD (Least Significance Difference). Spike length and spikelets per spike also showed a highly varied performance among all the genotypes, minimum spike lengths were observed (9.37cm), 9.83 cm (AWL9) and (AWL8), while maximum spike lengths were recorded for (AWL7) and (AWL22) 14.60, 14.38cm. The number of spikelets per spike in all the wheat genotypes ranged from 18.00 to 24.67. Among all the genotypes, a minimum number of spikeletes per spike was observed (AWL23) and (AWL21 (18.00 and 18.17cm) (Table 3a and 3b). While the maximum number of spikeletes per spike was recorded for AWL2 (24.67) followed by AWL5 (24.00). Analysis of variance showed a significant difference in biological yield among the tested 25 advanced wheat lines. Biological yield in all wheat genotypes ranged between 2675 to 4225 Kg h^{-1}. Among all the genotypes, minimum biological yield was observed for AWL19 (2675) followed by AWL10 (3000), while maximum biological yield was recorded for AWL5 (4225) and AWL25 (3800 Kg h^{-1}). The coefficient of variance is varied for different blocks respectively. Analysis of variance shows the significance of genetic variation for biological yield. The coefficient of variation (CV) was 8.05 at 5% probability showing 587.49 LSD (Least Significance Difference). Grain yield in all wheat genotypes ranged between 1800.00 to 3505.00 kg h^{-1}. Among all the genotypes, minimum grain yield was observed for AWL19 and AWL14 i.e. 1800.00 and 2180.00 Kg h^{-1} (Table 3b). While maximum grain weight was recorded for AWL25 and AWL23 i.e. 3505.00, 2827.50 Kg h^{-1} respectively. The coefficient of variance is varied for different blocks respectively. Analysis of variance showed the significance of genetic variation for grain yield. The coefficient of variation (CV) was 8.11 at 5 % probability showing 589.30 LSD (Least Significance Difference). Among all the genotypes, a minimum 1000 grain weight was observed for AWL3 (18.10) and AWL7 (43.95 g), while 1000 grain weights were recorded for AWL15 (67.70) and AWL5 (62.70 g).

Conclusions

The research work was carried out at Cereal Crops Research Institute Pirsabak (CCRI), Nowshera, Pakistan. The CCRI is located at 34-degree North latitude, 72-degree East longitude and 288-degree altitude. Experiments were conducted under irrigated conditions on 13 November 2021. The experiments were designed in a simple partially balanced lattice 8x8 with two replications. Each plot consisted of 4 rows of 2-meter length. The row spacing was 30 cm with a plot area of 2 m^2. A single row between adjacent plots was kept fallow to facilitate data recording. The agronomic practices and inputs were applied for all the entries from sowing to harvesting and the genotypes were grown under uniform conditions to minimize environmental variations. The days to heading data, plant height, flag leaf area, spike length, spikelets per spike, and 1000 grain weight for all the genotypes showed non-significance genetic variation respectively, and in contrast biological yield, days to maturity showed significant data variation. For days to heading AWL18 (156) showed more day intervals and AWL7 (137) showed early heading with a coefficient of variation was 3.21. In days to maturity, the late genotype was AWL7 (163) and the early genotype was AWL12 (156) with the coefficient of variation being 0.95. AWL4 (39.67cm) exhibited more plant height and the minimum for AWL11 (34.33cm) with a coefficient of variation being 4.29. flag leaf area, spike length, spikelets per spike, biological yield, and 1000 grain weight revealed maximum data for AWL12 (55.77cm^2), AWL7 (40.60cm) AWL2 (24.67), AWL5(4225 kg h^{-1}), AWL15(66.70cm) and minimum were shown for AWL9 (31.37cm), AWL9(9.37cm), AWL23(18.00), AWL19 (2675 kg h^{-1}), AWL3 (18.10cm), with the coefficient of variation 16.26, 15.42, 6.88, 8.05, 15.44, respectively. Of the total 25 genotypes AWL18, AWL7, AWL4, AWL12 and AWL2 outclassed lines were compared to check to cultivate gulzar19, a maximum number of days to heading, days to maturity, plant height, flag leaf area, spike length and spikelets per spike. In contrast, 1000 grain weight showed less significance data then Gulzar -19.

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